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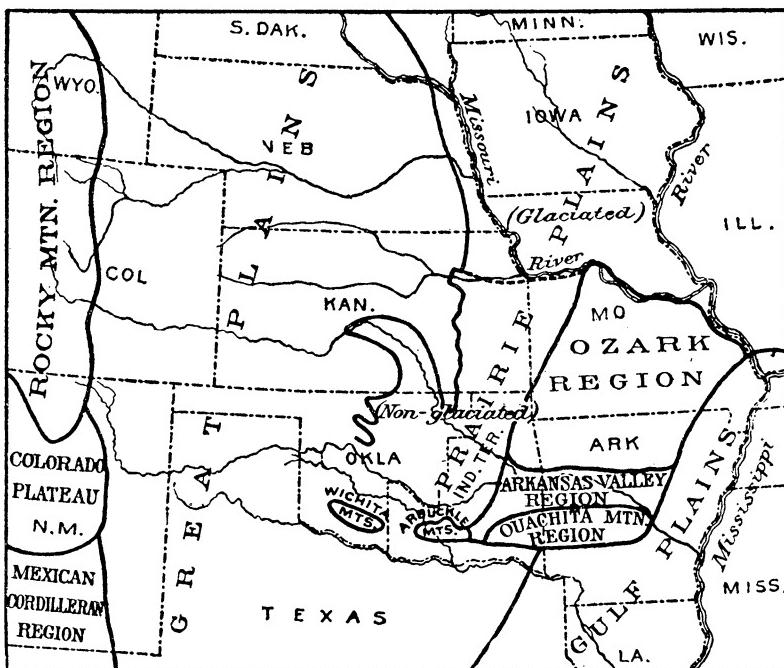
PHYSIOGRAPHIC DIVISIONS OF KANSAS.

By GEORGE I. ADAMS, Washington, D. C.

Read before the Academy, at Iola, December 31, 1901.

THE eastern portion of Kansas has only a moderate elevation above sea-level, the river valleys being about 750 feet above tide where they cross the boundary. The surface rises to a height of about 4000 feet in the northeast corner of the state, but the transition is gradual, and mountainous features nowhere occur. Isolated mounds, hills, ridges and escarpments are the boldest forms of relief, and are conspicuous in contrast with the broader stretches of gentle slopes, rolling prairies, terraced uplands, broad plains, and moderate stream valleys. While the topography of Kansas is that of a plains country, it presents an ever-pleasing variation to the traveler, or impresses him anew with its quiet grandeur. The text-book of geology is here so plain that he who runs may read in simple lessons the story of the formation of the earth and the manner in which it has been sculptured into pleasing features. There are no overpowering scenes, and, although there are broad problems, the mind is seldom perplexed when considering that which lies within the range of vision. It may be that this is the reason that the general features of the state have thus far not been outlined. There are many fine descriptions of impressive localities and isolated scenes, but no one has attempted to distinguish the units which constitute the physiographic divisions of the state. Most of them are already well described, but their limits have not been defined or shown on a map. It is the purpose of this paper to indicate as clearly as possible their boundaries and salient characteristics, and to supplement brief descriptions by quotations from the already voluminous literature.

The first general physiographic map of the United States published was that by J. W. Powell, in the National Geographic Monographs. The limits of the regions are there not closely defined, and subsequent study has shown the necessity of modifying them somewhat. The map of the physical divisions of the United States contained in Davis's Physical Geography differs from that of Powell in certain details, but it likewise is subject to revision. In the accompanying sketch map the results of a closer study of the regions adjacent to Kansas are presented. It is incomplete in part, especially in failing to show the limits of the regions in the southern portion of Oklahoma. It, however, presents clearly the physiographic relations



Sketch showing physiographic relations of Kansas, by George I. Adams.

of Kansas, the features of which it is the purpose of this paper to discuss.

The state of Kansas, with the exception of the extreme southeast corner, which is a portion of the Ozark region, lies within the Prairie Plains and the Great Plains regions. These divisions are characterized by their broader physical aspects and their simple geologic structure. They are not clearly defined by topographic differences, although they have a general unity of surface features and altitudes.

THE OZARK REGION.

The country here designated as the Ozark region has been discussed from various standpoints. In the following definition, it is considered as structurally related to the Arkansas valley and the Ouachita mountains:

Broadly defined, the Ozark region embraces the southern half of the state of Missouri, a very small corner of southeastern Kansas, the northeastern part of Indian Territory, and the northern part of Arkansas. . . . In a general way the Mississippi and Missouri rivers bound it on the northeast and north, Spring, Grand and Arkansas rivers approximately limit it on the west and south, while the upper portions of the St. Francis and Black rivers mark its southeastern margin. . . . In its northern portion it is to a large extent a rolling plain, and in its southern and more rugged part the broken character is evidently the result of erosion by streams which have deeply dissected a generally even sur-

face. . . . As compared with the Mississippi valley, the region is an elevated one. To the north and west of it lie the Prairie plains; to the east and southeast are the Gulf plains. . . . The structure of the Ozark region is simple. The Boston mountains, on its southern border, are of a monoclinal type, while the plateau portion, or northern part, has the form of a low dome, with local faulting and minor undulations. To the south of the Ozark region is the Arkansas Valley region, which has a folded structure, and beyond it the Ouachita Mountain region, which is closely folded and thrust-faulted. . . . In the southern portion of the Ozark region are the Boston mountains, which are a dissected highland extending through northern Arkansas, from Batesville to near Wagoner, in Indian Territory. The northern portion of the region is the Ozark plateau, which consists of two divisions. The eastern one is the Salem upland and the western the Springfield upland. They are separated by the Burlington escarpment. (Adams, Physiography of the Ozark Region, 22d An. Rep. U. S. Geol. Surv., pt. II, pp. 69-75.)

In the extreme southeast corner of the state there is a small portion of the Springfield upland. Its general surface is a structural plain developed on the Mississippian limestone. The plain is limited on the west by the valley of Spring river, which is located approximately along the contact of the Coal Measure shales. The portion in Kansas is the border of a westward-dipping structural plain, and, lying adjacent to the Cherokee lowland, is considerably reduced, and has but a slightly greater altitude. The country rock of the Springfield upland contains much flint. Its surface is accordingly in strong contrast with the lowlands to the west, which are developed on soft shales and sandstones. The limestones, which constitute the upland, contain valuable deposits of lead and zinc. The principal town of the area is Galena.

PRAIRIE PLAINS REGION.

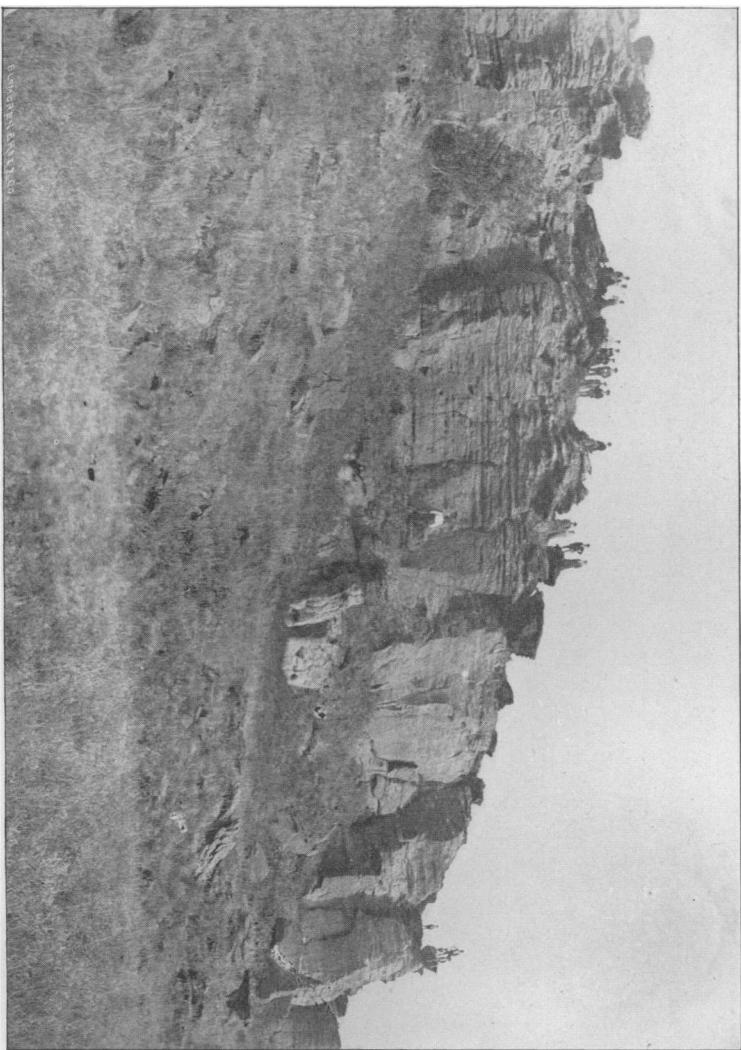
The Prairie Plains region embraces that portion of the Mississippi valley which lies at a moderate elevation, and in which the processes of reduction have brought the surface of the country to a generally level plain. Its surface features have been developed by erosion, and mountainous structures are nowhere present. The changes of level which the Prairie plains have undergone were relatively slight as compared with the mountainous regions which have been the centers of the disturbances. To the northeast of the Prairie plains are the Lake plains, which are related in their development to the Great Lakes. To the south of the Prairie plains are the Gulf plains, which have been developed as a result of the oscillations of the Gulf of Mexico. To the east and west the Prairie plains pass by easy gradations into higher altitudes and into higher plains or plateaux, which are adjacent to the Appalachian region and the Rocky Mountain region. It will thus be seen that the Prairie plains occupy an intermediate position in the Mississippi valley. Their physiographic history is related to that of the regions on the north, east, south, and west.

Lying near their center, in southern Missouri, eastern Arkansas, and the Indian Territory, is an area which has a mountainous structure. As a result of continuous erosion by streams since the establishment of the drainage system of the Mississippi valley, the Prairie plains encroach upon its flanks. Another factor in the development of the Prairie plains was the advance and retreat of the ice sheet which covered their northern portions in glacial times, sculptured the surface, and left behind upon its retreat vast accumulations of rock material. This portion of the Prairie plains is known as the glaciated, in contrast to the southern, or non-glaciated, division of the region.

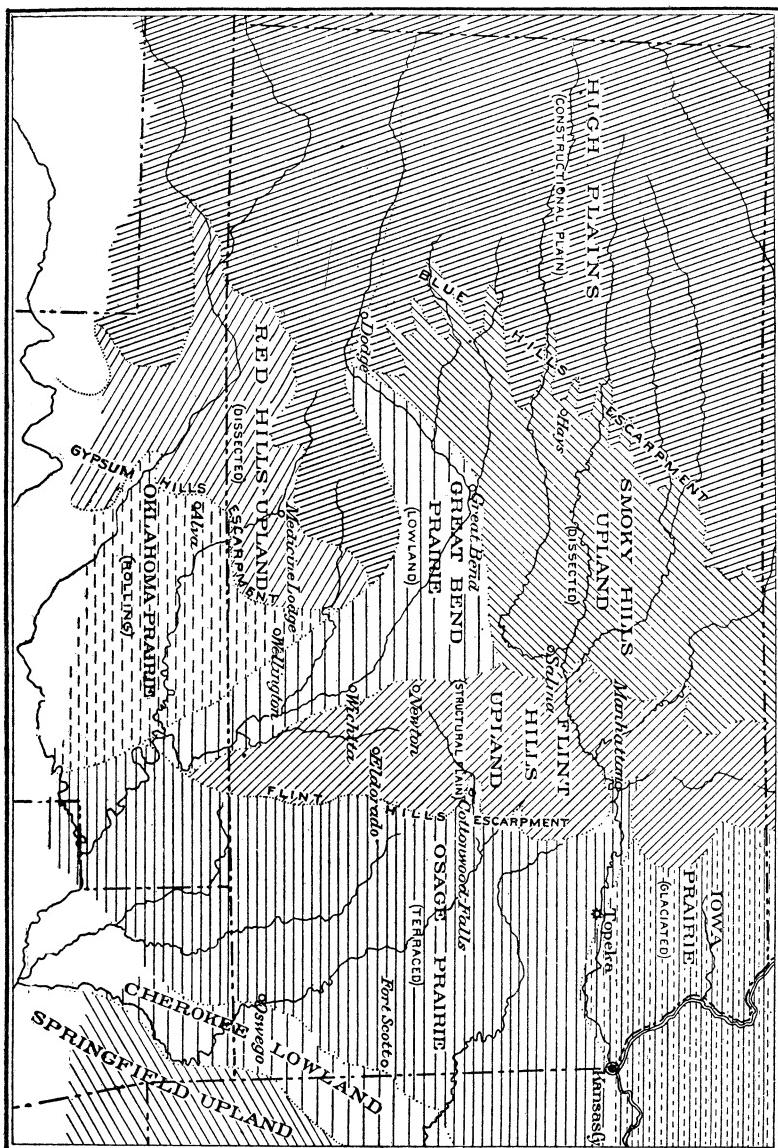
To the west of the small area of the Springfield plain in the southeastern corner of the state there is a belt of low-lying country known as the Cherokee lowland. This area continues in Missouri, and has there been called the Nevada lowland; it also extends into Indian Territory along the valley of the Neosho or Grand river, where it merges with the lowland plain of the Arkansas Valley region. The lowland is developed on the soft shales and sandstones which form the base of the Coal Measures in Kansas. The shales have a thickness of about 450 feet, and are exposed over a belt of country approximately twenty-five miles wide, within which are situated Cherokee county and portions of Crawford and Labette. In Missouri the area tapers to a point, as a result of the overlapping of the higher beds which form its western border onto the rocks of the Springfield plain.

The surface is gently undulating, the monotony of lowland topography being occasionally broken by ridges and mounds which occur on the divides and owe their existence to heavy sandstones. Such a mound is the one west of Baxter Springs, near the territorial line. The country around Columbus exhibits a number of sandstone ridges, the city being located upon the divide between Spring river and the Neosho. . . . The western border of the Cherokee uplands is the Oswego escarpment, which is produced by the first important limestones in the Kansas section of the Coal Measures. This formation is known as the Fort Scott limestone, and at Oswego caps a bed of shales, producing an escarpment which along the river bluff is 120 feet high. (Adams, Physiography of Southeastern Kansas, Kan. Acad. Sci., vol. XVI, p. 57.)

The surface of the lowland is gently undulating, with watercourses flowing in wide, flat-bottomed valleys bordered by low, gentle slopes. Toward the western side of the valley outliers of the escarpment bordering the northwestern side relieve the general monotony of the landscape. The whole area is practically down to grade. It is already a lowland of denudation. It has long since passed through its stage of most pronounced relief and is now gradually wiping out the varieties of its surface. On the softer rocks, in the vicinity of Clinton, the general level is in many places less than fifty feet above the level of the flood plains of the streams. . . . The area of the soft beds has been exposed to degradation no longer than that of the hard limestones comprising the Springfield structural plain, yet the soft ones have reached old age in the cycle, while the harder ones are in a vigorous youth. (Marbut, Mo. Geol. Surv., vol. X, p. 67.)



Roaring Spring Cliff, Ellsworth county, Kansas. Showing Escarpment of Dakota Sandstone
Left through erosion.



Map showing physiographic divisions of Kansas, by George T. Adams

The Iowa prairies, that portion of the division of the Prairie plains which lies in the northeast corner of Kansas, owes its peculiar surface features to the fact that the rock formations are covered with a mantle of drift, deposited during the glacial period. The southern border of the glaciated area is a line approximately along the Kansas river in Kansas, and from the mouth of that stream along the Missouri river in Missouri. Since the deposition of the drift the streams have cut their channels deep enough to expose the underlying rock formations and revive in modified form the original topographic features. As a result, there are in places fragments of terraces and escarpments similar to those which prevail in the Prairie plains south of the glaciated portions. No attempt is made to define the limits of the Iowa prairies beyond the boundary of the state. They extend into Missouri, and find their larger development to the northeast in Iowa.

Northeastern Kansas is the southwestern corner of Iceland—that is, it is the southwestern part of the area which, in the times immediately succeeding the Tertiary age, was covered with ice. . . . Where the ice halted and its terminus remained stationary for a time, the melting being exactly met by the supply from the north, there was formed a terminal moraine as a result of the accumulation of the solid matters it had carried along with it. . . . The true hard-pan or till is a stiff, pasty, dark-brown clay, with pebbles and small boulders. It seems to have been formed under the ice by the grinding of the material over which the glacier passed—clay shales, soft limestones, and sands. . . . The loess is often called bluff, because the bluffs of the Missouri river are formed of it or capped with it. . . . Over immense areas it is substantially the same material as that which gives color and muddiness to the water of the present river. In some regions it takes color from local surroundings, and has streaks of coarse sand or gravel, and becomes of orange brightness. (Hay, 8th Bien. Rep. Kan. St. Bd. of Agri., vol. XIII, part II, pp. 118, 119.)

Boulders lie scattered in small numbers in detached areas, north of the Kansas river, from the Missouri nearly to the Republican, but west of the latter none are noticed. The drift gravel extends a little farther. The origin of our drift, like all others in the northern hemisphere, must be sought in regions far to the north. No original ledges of quartzite or other metamorphic or igneous rock are found within 300 miles of the northern state line, and it is only in the western portions of Minnesota that these deposits are represented. No other material of our drift is found so near. . . . The larger stones attain the size of true boulders, being sometimes ten feet in length, and weighing ten or twelve tons. The most common are a metamorphic, stratified quartzite rock. The metamorphic action has been very thorough, giving the boulders a hardness equal to common quartz, and on that account they are frequently known under the name of "hard heads." . . . The large boulders are usually angular, and not so much water-worn as the small pebbles. Next to quartz rock the most common material is greenstone. A few of granite and syenite are also seen, but seldom as large as the quartzite or greenstone. The deposit of drift material is not deep, being about five feet, though in a few places it is twenty feet. The large boulders are quite numerous on the Pottawatomie reserve, on both sides of the Kansas. They lie on the tops of the bluffs and high prairies more frequently than on the lower lands. (Mudge, 1st Bien. Rep. Kan. St. Bd. of Agri., vol. VI, 2d ed., 1877-'78, pp. 51, 52.)

The Osage prairies have as their distinguishing features a series of terraces which have been formed by erosion of the interstratified Carboniferous shales, sandstones, and limestones. The rocks have a northeast-southwest strike, and the harder beds, being more resistant, produce escarpments which, with many deviations, follow this direction from the Kansas river into the Indian Territory, although none of them extend unbroken for the whole distance. The resistant beds in Kansas are largely limestones, which outcrop at the top of the escarpments and on the surface of which back slopes are developed. In the Indian Territory the limestones disappear and sandstone formations assume their rôle in the topographic features. The line of transition from sandstone escarpments to limestone escarpments is an irregular V, extending northward from the Indian Territory, with its point approximately at Yates Center, in Kansas.

The drainage of the Prairie plain is due primarily to the eastward slope of the surface. . . . In general the dip is westward, and the streams flow at right angles to the strike, but slight deformations of the strata have caused a deflection of some of the streams to the southward. . . . The formations over which the streams flow are beds of limestone, alternating with beds of sandstone and shale. The unequal yielding of these materials to erosive agencies has produced in general a terraced surface, the limestones protecting the escarpments, while the shales and sandstones below have been carried away by the streams. The inclination of the strata has produced a gradual slope (back slope) from the top of one escarpment to the base of the next higher. (Adams, Kan. Acad. Sci., vol. XVI, pp. 56, 57.)

If one passes across the country from southeast toward the northwest, he will be continuously passing up a series of terraces. . . . Here and there, wherever there is a line of outcrops of an important limestone, there is a more or less pronounced escarpment facing the southeast. . . . If the escarpment is bold, and the underlying shale-bed is thick, a series of mounds always exists to the southeast of the escarpment proper. These have plainly been produced by the erosive agencies breaking through protecting limestone further to the west. Such mounds sometimes are large, with broad, flat tops, as is well illustrated by Table mound, northwest of Independence. Sometimes they have the form of a frustum of a cone, so beautifully illustrated in the vicinity of Cherryvale and Mound Valley. At other times, as at both these places, the protective limestone is still maintained on their summits. In some instances the surface limestone has been gradually worn away until the material consists entirely of masses of shale, which may have a little sandstone interspersed. In these cases the summit of the mound is rounded. . . . It is interesting to note how the great areas of mounds and escarpments coincide so exactly with the southeastern limits of the shale-beds. Beginning at La Cygne and Boicourt, we have an area characterized by mounds and steep bluffs, reaching to the southwest by way of Mound City, Uniontown, Cherryvale and Mound Valley to beyond the limits of the state. [To the west there is] a similar topography in the vicinity of Neodesha and Independence. [Passing further along, similar features extend] from Osawatomie to the southwest, by the way of Lane, Greeley, and Garnett. . . . At Lawrence, Blue mound stands off five or six miles to the east of the general outcropping of the limestone which forms its protective cap. . . . We find

but few rolling areas anywhere within the Carboniferous. The tributaries of the different streams have cut the whole country into valleys, and the residual portions, which have not been carried away by erosion, constitute the hills, so that usually there is such a succession of hills and valleys that the whole country is not only well drained, but moderately rugged. While one may travel for miles in the direction of the ridges almost on a level, in a transverse direction deep valleys will be found. (Haworth, Univ. Geol. Surv. Kan., vol. I, pp. 213-215.)

The sandstone beds, which give rise to heavy escarpments in the Osage prairies in the Indian Territory, are succeeded in eastern Oklahoma by softer beds and a succession of formations, which, being generally homogeneous in character, do not give rise to escarpment features. The portion of the Prairie plains lying in eastern Oklahoma may be characterized as the rolling plains, in contrast with the terraced surface of the Osage prairies. To them the name Oklahoma prairies is here given. The area is traversed by streams which flow in a general eastward direction, but which are deflected toward the south. The divides are gentle, and no very decided differences of elevation exist throughout the area. The country rock and soil of this area are generally red, and are a portion of what has been called the Red Beds, which are a color phase of the Carboniferous and Permian formations. The western limit of these prairies is marked by a conspicuous escarpment, known as the Gypsum Hills escarpment, which passes from the Glass mountains, on the Cimarron river, in Oklahoma, to the west of Alva, and thence into Barber county, Kansas. Only a small portion of the Oklahoma prairies lies in the state of Kansas. It is triangular in form, and includes the western part of Sumner and Sedgwick counties, and a portion of Harper and Kingman. The line of division between the Oklahoma prairies and the Great Bend lowland is naturally not well marked by topographic features, but is drawn relative to the area over which the streams have migrated as a result of the local base-leveling of the Arkansas river.

The Arkansas river along its course in Kansas, where it makes what is known as the great bend, flows in a shallow channel. Its valley comprises a broad stretch of generally diversified lowlands, which represents a local base-level of the stream. In this portion of its course the river lies on the easily eroded Paleozoic shales and the shaly beds of the Dakota formations, and, together with its tributary streams, has, in the course of its meanderings, reduced the country to a generally level plain. The western limit is found along the course of the stream from Larned to Great Bend, where it impinges against the Dakota sandstones. Its southern limit lies in Oklahoma, where the river, in passing around the southern end of the Flint hills and eroding its channel across resistant beds, has been confined to a narrow valley. The area of the Great Bend lowland is largely covered

with sandy accumulations, which in places form sand-hills and in other localities are spread out as a thin mantle. The Equus Beds, in McPherson county, belong to this formation. The eastern boundary of the lowland is the line of intersection of the structural plain of the western slope of the Flint hills with the level country of the Arkansas valley, and is not strongly marked by any topographic features. It may be drawn with reference to the occurrence of the limestones, on the surface of which the Flint Hills upland is developed. The Great Bend lowland, considering its elevation and general surface features and its relations to the other divisions of the prairie plains, is a natural part of them, although it forms an arm extending between the uplands of the Great plains.

The explanation of the origin of the great bend of the Arkansas river, given in the following quotation, was outlined by the writer when in the field, and was subsequently embodied by Haworth in his report: "One of the most notable features in connection with the Arkansas river is the great and unusual bend it makes in passing from eastern Ford county so far to the north to Great Bend, and back so far to the south. . . . It would seem that when the river reached the Dakota formation, a formation so easily corraded, it immediately began acting upon it with great vigor. As the general inclination of the strata of the Dakota is to the northeast, . . . and the Dakota sandstones are easily corraded, it would seem that this was the cause of the river's great bend to the north. We may safely believe that at an early period in the history of the river it passed eastward from Ford county across the north of Kiowa, Pratt and Kingman counties, probably passing out of the state not far from its present location. If this explanation is correct, one cannot help inquiring why the river did not break through the upland, in the vicinity of McPherson county, and ultimately join the Cottonwood river through Marion and Chase counties. To answer this clearly, we only have to look at the general geologic character of the southern part of the Flint Hills in Butler and Cowley counties to find an adequate reason. The great Flint hills area has its surface rising to points considerably higher than the main uplands of Sumner and Sedgwick counties. Evidently these high elevations in the the early Tertiary times deflected the river southward, and prevented it from crossing the Flint Hills region when the drainage was first changed to an easterly direction by elevation of the Rocky Mountains. The same Flint Hills area has continuously remained higher than the uplands in Sumner, Sedgwick and adjoining counties. Therefore, with the river once flowing out of the state near where it now does, it would be impossible for it to pass eastward across the Flint hills so long as the elevations remain as they now are." (Haworth, Univ. Geol. Surv. Kan., vol. II, pp. 30-32.)

GREAT PLAINS REGION.

The Great Plains region, or, as it might properly be called, the Great Plains plateau, lies between the Prairie plains and the Rocky Mountains, its limit not being marked by sharp differences of elevation or changes in topographic features. It is crossed by a number of streams which head in the mountains and in their lower portions unite to form the great river system of the Mississippi valley and the drainage of the western Gulf coast. The Great plains extend north

and south, including the median portion of these streams, and within their area corrosion varies with the varying conditions of climate and the grade of the country. All of the processes which are now at work are dissecting the Great plains. This has not always been their condition. In Tertiary times the sediments carried from the Rocky Mountains were spread in a broad sheet extending eastward from their base, and built up a constructional plain. This plain is largely preserved to the present time, and constitutes the division known as the High plains.

The elevation of the Great plains increases very gradually to the westward, and their surface is not marked by conspicuous features of relief. Their more rugged portions are where the Tertiary formations have been sculptured into bad lands and cañons, or the areas of the older rocks have been dissected by the streams. The Bad Lands type of topography is found principally along their western border, the High plains, or intermediate portion, being simply trenched by the streams crossing ft.

The Flint Hills upland is a name suggested for a somewhat irregular belt of country which extends from north to south across the state and terminates in a point north of the Arkansas river in Oklahoma. It is in its southern part the divide or watershed between the Neosho and Verdigris drainage on the east and the Arkansas drainage on the west and south. The Kansas river is the only stream which crosses the upland. The Cottonwood river heads within its limits near the western border, and flows eastward, extending nearly across the area. The eastern border of the upland is marked by a compound escarpment, which is produced by the outcrop of limestones. This feature is well defined at its southern portion, where it is emphasized by the position of the stream valleys. The removal of the shales, which succeed the highest beds of limestones, has given rise to a structural plain developed on the upper surface of these resistant beds. This plain has a gradual western dip, corresponding to the dip of the rocks, and constitutes the general surface of the upland. It blends along its western border with the Great Bend lowland and the valley floors of the Smoky Hills upland. Its southern portion has suffered considerable dissection, and is known as the Flint hills, from which the name of the upland is derived. The northern portion of the upland is dissected by Little Blue and Big Blue rivers, which flow southward from Nebraska approximately along the strike of the formations. They have developed well-defined valleys, and their numerous short tributaries have sculptured out terraced hills and divides, producing a quite rugged topography.

The Flint Hills upland has no doubt had an influence in determin-

ing the course of the Arkansas river within the state. This stream, after making a peculiar bend, parallels approximately the western border of the upland into Oklahoma, where it finds its way around the south end. The streams of the northern part of the state have likewise adjusted themselves to the structure of the rocks on the western border of the upland, and joined their volumes in maintaining the valley of the Kansas river across it. In determining the disposition of the drainage from the Great plains, the Flint hills upland likewise determined the former distribution of the Tertiary formations by deflecting the streams carrying the sediments, or retarding the velocities of those eroding their channels across its resistant beds and causing them to drop their loads. The eastern margins of the Tertiary formations have been largely removed. Judging from their present extent and relations, as well as the distribution of materials derived from them, we may safely assume that they did not transgress eastward in Kansas farther than the boundary of the Flint Hills upland. The following description of the Flint hills, which present the most pronounced characteristics of the upland, is principally from observations along the railway, extending from Moline to Winfield, crossing their most broken portion :

The Flint hills extend in a general north and south direction, and occupy approximately the southern part of Chase county, the western borders of Greenwood, Elk and Chautauqua counties, and the eastern portions of Butler and Cowley. Fall, Elk and Big Caney rivers, which are tributaries of the Verdigris, have their sources in the many small streams cutting the eastern escarpment of the Flint hills. The streams on the western slope (structural plain) are tributaries of the Walnut. The Cottonwood, a tributary of the Neosho, sweeps in a broad curve to the north, around the head waters of the two drainages above mentioned. . . . The divide between these several streams, with its uneven configuration, is known as the Flint hills. . . . The general position of the ridge may be located on a map by the significant names of the towns—Flint Ridge, Summit, Beaumont, and Grand Summit. In their southern portion, where crossed by this section, the valley of Grouse creek, which extends from north to south, divides them into two ridges, the eastern of which is known as the Big Flint hills, and the western as the Little Flint hills. . . . To the north of the Flint hills, as here defined, the same geological formations are exposed in the valley of the Kansas river and its tributaries, and give rise to the terraced bluffs which are characteristic of the country around Junction City and Manhattan. . . . The Flint hills derive their name from the large amount of flint which is found over their surface. Nearly all the limestones composing them contain some flint, and a few of them carry heavy beds of it. The weathering away of the limestones has left the enclosed masses of flint, which are strewn over the surface in such profusion as to seriously interfere with travel. . . . The Flint hills owe their contour wholly to erosion, there being no evidence whatever of marked disturbances of the strata, which occupy nearly horizontal positions [with a low dip to the westward]. They are characterized by even terraces and small cañons and gulches. Along the top of the terraces, which are covered

with a scant growth of grass, the various limestone systems are seen in parallel ledges, and are very conspicuous on account of their whiteness. . . . (Adams, Univ. Geol. Surv. Kan., vol. I, pp. 27, 28.)

The higher formations of what is generally referred to as the Red Beds in Kansas and Oklahoma contain resistant rocks at several horizons, and erosion has developed within their area a distinctly different surface from what is found in the Oklahoma prairies. The line of separation between these two divisions is the Gypsum Hills escarpment, already referred to. The topographic forms of common occurrence are small, table-like plateaux and flat-topped hills, which are the minor elements. The area is a dissected upland, with its western border grading to the High plains without perceptible difference of elevation—the rise in surface to the westward being accomplished by a series of steps within the upland. The Red Hills upland has already been well described by several authors. The following descriptions are particularly applicable to them:

In eastern Barber county, in the buttes to the north of Sharon and the Cedar hills to the south, the rugged and picturesque country of the Red Beds begins. . . . This region, with frequent steep buttes and streams lined by steep bluffs, extends across Barber, Comanche and Clark counties to the eastern part of Meade. The best exposures of the middle portion of the series of rocks forming them, as well as some of the most picturesque parts of this country, may be seen in Barber county, in the Cedar hills, and along the steep line of bluffs and hills to the west of the Medicine Lodge river, especially in the Gypsum hills to the southwest of the city of Medicine Lodge. When seen from the hills to the east of Medicine Lodge, at a distance of ten miles, in the early morning sunlight, they form a landscape of striking beauty, which, once seen, will never be forgotten. The reddish color of the steep sides of the hills, whose walls suggest gigantic fortifications, is clearly visible, while the top of the hills appears in the hazy distance like a great table-land. (Prosser, Univ. Geol. Surv. Kan., vol. II, pp. 84, 85.)

If, on the road from Harper to Medicine Lodge, the traveler finds himself looking westward across the valley of Medicine Lodge river, on one of those enchanting days for which southern Kansas yields the palm to no other locality, the autumn air being tinged with just enough of haze to purple the remoter vistas of the ruddy landscape, "The splendor falls on castle walls" which rear themselves seemingly as low mountains or buttressed escarpments of a table-land crowning the further incline of the valley and bounding a considerable part of the western horizon. (Cragin, Colo. Coll. Studies, vol. VI, p. 28.)

The whole country is red. The soil, even where it contains much carbonaceous matter, is ruddy; the sedimentary soil just forming on the steeper slopes is redder; flooded rivers glance in the sunlight like streams of blood; steep bluffs and the sides of narrow cañons pain the eye with their sanguine glare. The hard ledges are persistent for long distances, and give a definite contour to weathered bluffs and ridges. . . . One of these layers south and west of the Medicine river is persistent over a considerable area. The erosion of the valley has left it nearly at the top of the area in which it appears, showing as an irregular plateau sloping east and north to the river. . . . In the lower valley the western boundary of the white sandstone plateau is a solid wall of red rock rising



Mushroom Rock, Ellsworth county, Kansas. Showing peculiar erosion type in Dakota Sandstone.

above it nearly 200 feet, surrounded by a great white coping of gypsum from twelve to fifteen feet thick. The wall runs southward for several miles, with some openings, and terminates abruptly by a turn directly west. Northward its termination is a bold promontory, and the neck, with gypsum absent from it in places, is only wide enough on the top for one person to walk. From this point the wall retreats, forming a deep amphitheater, with isolated buttes, and towers, and caps, and all up the western valley towers, pinnacles and buttresses are repeated, advancing toward or retreating from the river. When approached, the lights and shadows on the gypsum have the appearance of quaint gables and mansard roofs. (Hay, 8th Bien. Rep. Kan. St. Bd. Agri., vol. XIII, pt. II, pp. 106, 107.)

The portion of the state which is included in the Smoky Hills upland division is the north-central part. It is so named from the Smoky hills, in Saline county, which have also given their name to the Smoky Hill river. The formations found in the upland are the Upper Cretaceous rocks. The area may be referred to as denuded, considered with reference to the country to the west, which is covered with the Tertiary formations. It is not improbable that the Tertiary beds, which form a constructional plain in the western portion of the state, since the close of the period of their deposition, have been removed by erosion from a large portion of the area of the Smoky Hills upland. The topographic features are largely of indistinct-terrace and broken-escarpment type, with occasional lone hills or mounds. Along the southeastern border there are a number of places at which the more resistant sandstone horizons of the Dakota have given rise to features such as Pawnee rock, in Barton county; Smoky Hill buttes and Soldier Cap mound, in Saline county; and the Pulpit rocks, resembling perched glacial boulders, at Rock City, Ottawa county. Similar hills and groups of mounds occur in Lincoln, Ellsworth and Russell counties, being there also formed by Dakota sandstones. The upland is traversed by a large number of streams flowing eastward in nearly parallel channels and having moderate valleys. The divides between them have a general uniformity of broken slopes and gentle terraces. The rocks which constitute them outcrop principally along the streams as bluffs, and in places form the walls of cañons. The area of the Benton formation is more regular in its topographic features than the Dakota, since it consists of interstratified limestones and shales of a quite uniformly varied character. Toward the western border of the upland the Fort Hays limestone and Niobrara chalk (which succeeds it) are the protecting element in what is known as the Blue Hills escarpment. The Blue hills proper are generally considered as occurring in Russell county and extending to the north and south for some distance. The same general feature extends along the entire line of outcrop of the formations, and the name is here extended to the escarpment produced by them. The softer

beds of Benton shales underlying the resistant limestones are known as the Blue Hill shales, from the same locality. It is the erosion of these beds which gives rise to the escarpment.

Across central Kansas, from north to west of south, stretches a belt of country marked in ravines by rugged sandstone rocks and by long, rounded slopes on the prairie. This belt belongs geologically to the part of the Cretaceous system known as the "Dakota formation." To travelers on the Central Branch railroad, passing through Washington and Cloud counties, these sandstones are conspicuous objects. On the line of the Kansas Pacific, the same sandstones, underlain by colored shales, make the wild country from Bavaria by old Fort Harker to Ellsworth. . . . Further north, in Ellsworth county, are ravines with precipitous sides, on some of which a lost race have carved hieroglyphics of war and travel; and there are huge single rocks, like giant pulpits, standing out and alone. In Russell county are the worn pinnacles and crags of Rock City, and in Ottawa county the quaintly rounded concretionary masses of another rock city. . . . (Hay, 8th Bien. Rep. Kan. St. Bd. of Agri., vol. XIII, pt. II, pp. 109, 110, 111.)

A large portion of western Kansas is included in the High plains. Their eastern boundary is defined by the Blue Hills escarpment in the northern part of the state. South of the Arkansas river they merge with the undissected western margin of the Red Hills upland. The western limit of the High plains lies well toward the foot-hills of the Rocky Mountains, in Colorado. Their north and south extent has not yet been defined with any degree of definiteness. They correspond with what has sometimes been called, for convenience, the Central plains, and form an irregular belt midway in the long eastward slope of the Great plains. They are characterized by a general dead-level surface when viewed in their broader aspect. Their surface is a constructional plain, which has survived in large measure since the close of Tertiary times. The divides between the streams are flats or fragments of an extended surface which was formed by the spreading of a quite even mantle of Tertiary sediments over the older rocks, which are principally of Cretaceous age. The valleys, which are scored into the Tertiary and often expose the Cretaceous, are relatively but slight furrows compared with the broad extent of level land. Along the larger streams, however, are found occasional striking erosional forms, which are all the more conspicuous because of their occurrence in the High plains. Cretaceous formations, which are exposed where the rivers have cut through the Tertiary beds, give rise to cañon walls along the small tributaries, and in the broad valleys remnants of them occur as bluffs and standing rocks. The Dakota is seen at Point of Rocks, on the Cimarron river, in Morton county, and the bluffs on Bear creek, in Stanton county. The Benton and Fort Hays limestones occur along the bluffs of the Arkansas river and its tributaries in Hamilton county. The Niobrara, however, gives rise

to by far the more picturesque features. It is exposed on White Woman creek, in Greeley county, at Wild Horse corral, and at many points along the Smoky Hill river. The Niobrara chalk has the peculiarity of weathering with vertical walls where it is of homogeneous character, so that in many places it has been eroded into picturesque landmarks. Castle rock, in the valley of the Hackberry, about ten miles from its mouth, is a lone pyramid composed of this rock, and separated by a considerable interval from the main bluff. Monument rocks, on the Smoky Hill river, are famous landmarks, and formerly a stage station of the overland route was located at them. Another picturesque group of rocks, which at a distance resembles the ruins of many castles, is situated west of Elkader, in the Smoky Hill valley. The Fort Pierre shales in Sherman county have been eroded into a number of hills, which are capped with Tertiary conglomerate. In traveling across the High plains one recognizes the fact that they constitute the typical portion of the Great plains. The following description is applicable to the High plains not only in Kansas but in their extent beyond the limits of the state:

The High plains, of unconsolidated material, above grade, and exposed to a considerable precipitation, are held by their sod. . . . The great plateau surfaces of the High plains have to show no systems of drainage, because, presumably, from the commencement of the present erosive stage, they have been sod-covered, as at present. In other words, the High plains have endured as alluvial plateaux since Tertiary times, or at least since the opening of the Pleistocene. While degradation is at a standstill upon the plateau surfaces, the topographic belt which they constitute has, however, been appreciably narrowed within a corresponding climatic belt by marginal recession. The limiting bluff, especially, that faces eastward, is carried backward by sapping on the part of small streams or feeble beginnings of streams, originating in springs and "seeps" at the bluff foot. . . . Agreeing generally in position with the topographic subdivision of the High plains is also a subdivision by climatic difference. In their westward rise of thousands of feet, the Great plains pass through climatic gradations from humid to arid. . . . (Johnson, 21st An. Rep. U. S. Geol. Surv., pt. IV, pp. 610, 629.)